Supplementary File
Figure Enlargements

Electronic Journal of
SEVERE STORMS METEOROLOGY

Geerts, B., T. Andretta, S. Luberda, J. Vogt, Y. Wang, L. D. Oolman, J. Finch, and D. Bikos,2009: A case study of a long-lived tornadic mesocyclone in a low-CAPE complex-terrain environment. *Electronic J. Severe Storms Meteor*., **4** (3), 1-29.

A Case Study of a Long-lived Tornadic Mesocyclone in a Low-CAPE Complex-terrain Environment

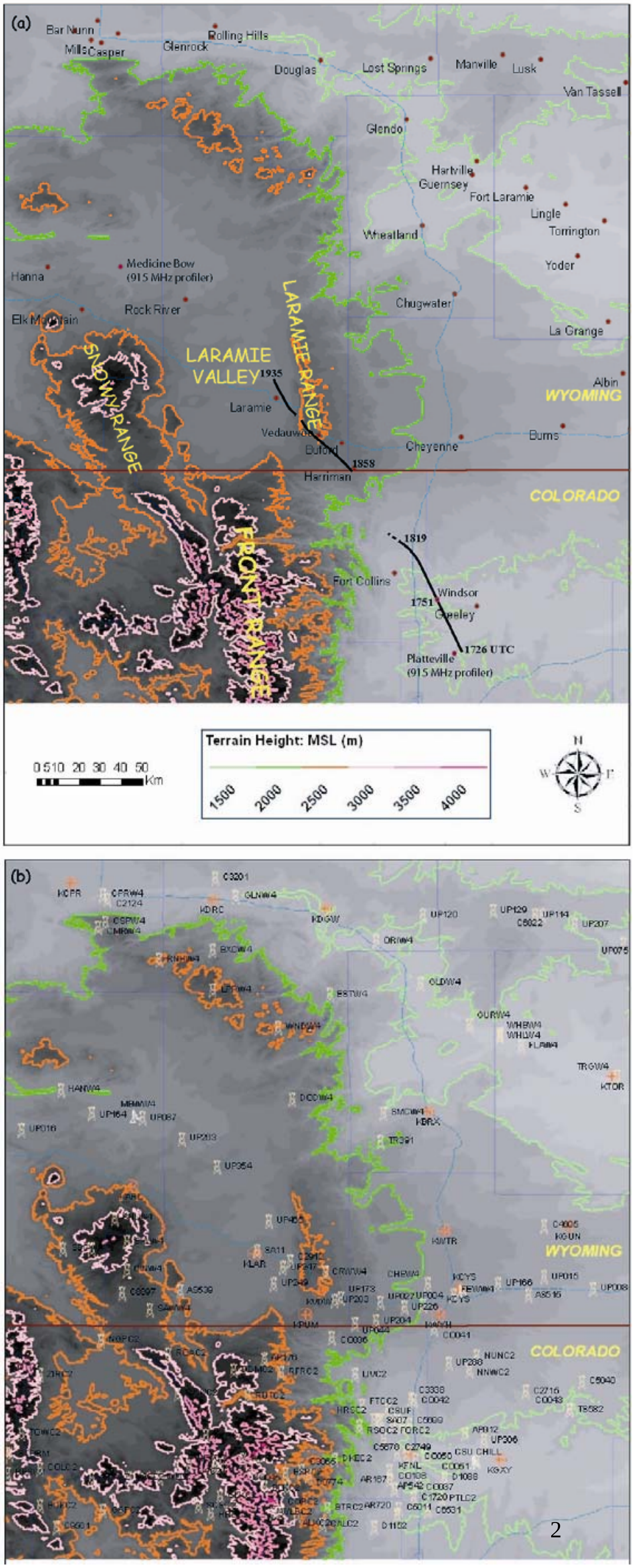


Figure 1: (a) Topography, state and county boundaries, interstate highways, and cities in the inner (meso-β scale) domain of the WRF simulation. Terrain elevation is shaded and color-contoured at 500 m intervals. Black paths denote tracks of 22 May 2008 tornadoes near Windsor, CO and Laramie, WY, based on a National Weather Service (NWS) damage survey and eyewitnesses (Finch and Bikos 2009). b) As in (a), but with the all *Mesowest* station locations shown as towers (non-METAR) or airports (METAR), and the location of the KCYS and CSU CHILL radars (radar symbol).

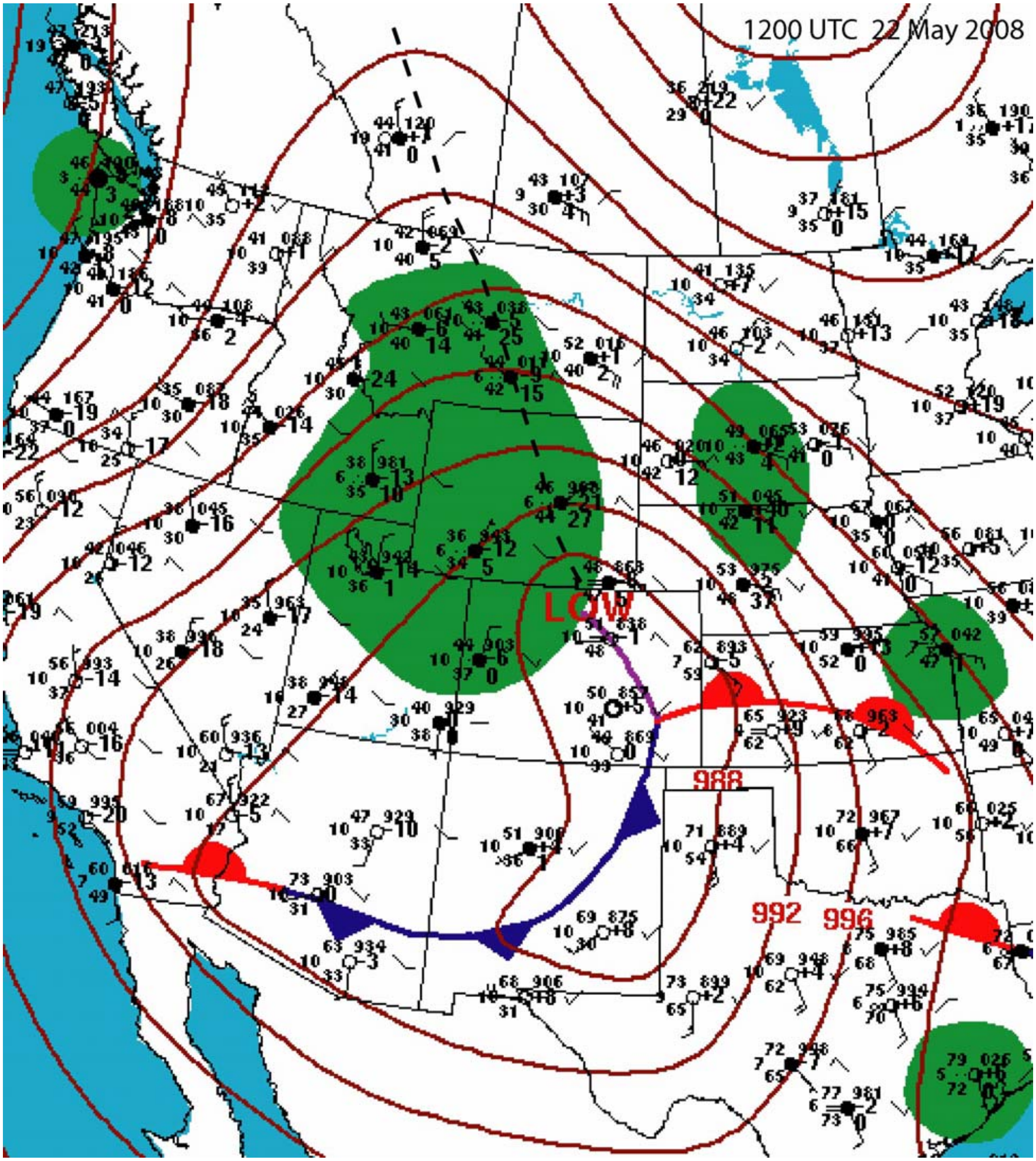


Figure 2: Hydrometeorological Prediction Center sea-level pressure and frontal analysis at 1200 UTC 22 May 2008. The green shading highlights the area with precipitation. We added the trough axis north-northwest of the low, as a dashed line.

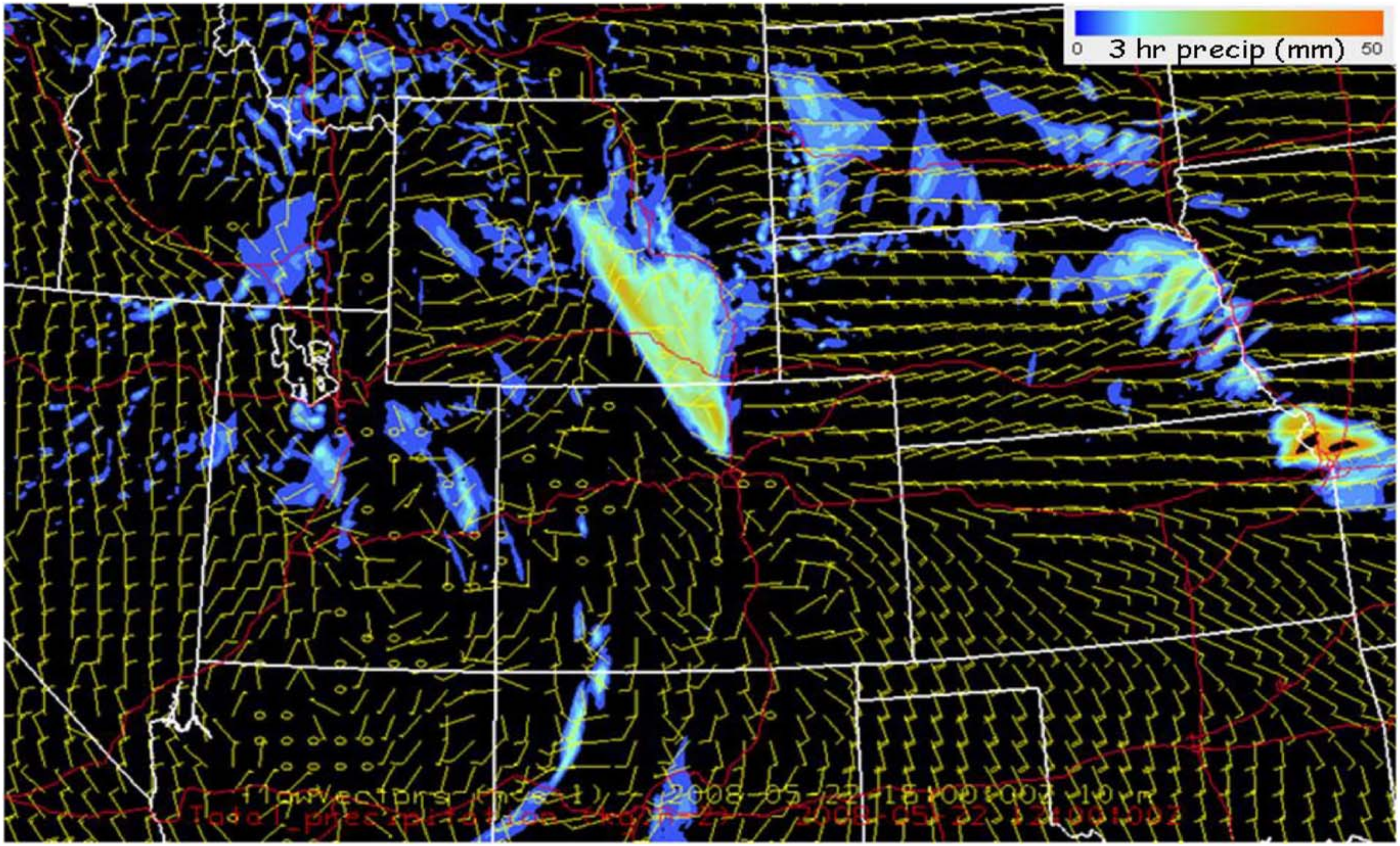


Figure 3: Surface wind barbs (full barb is 5 m s^{-1}) and 3 hour total precipitation (color fill, units mm, minimum plotted value 0.25 mm) at 1500 UTC 22 May 2008, from the WRF-NMM initialized at 6 UTC. Red lines are interstate freeways.

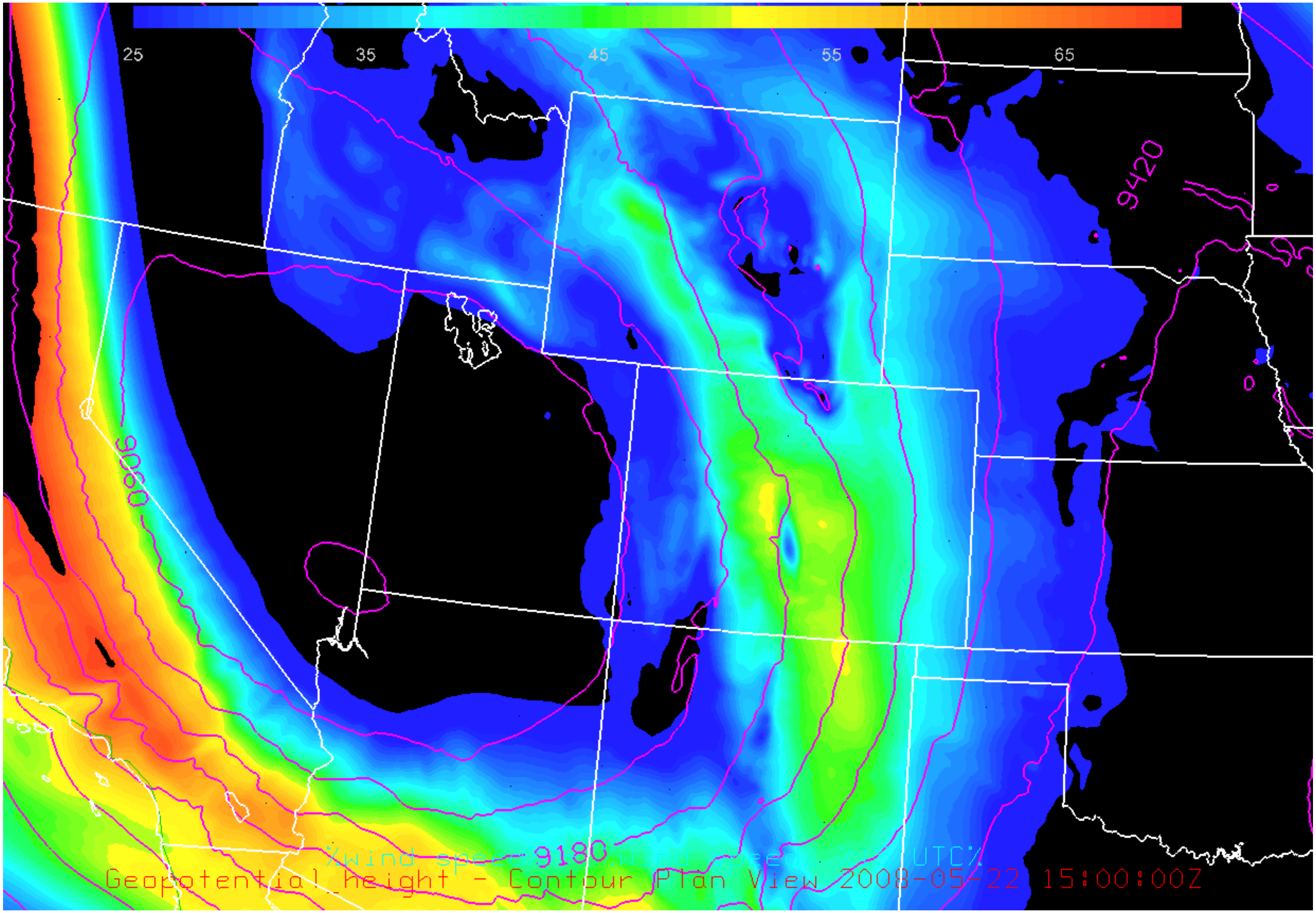


Figure 4: WRF-NMM 300 hPa height (magenta contours, 60 m interval) and isotachs (color fill, between 25-70 m s^{-1}) at 1500 UTC.

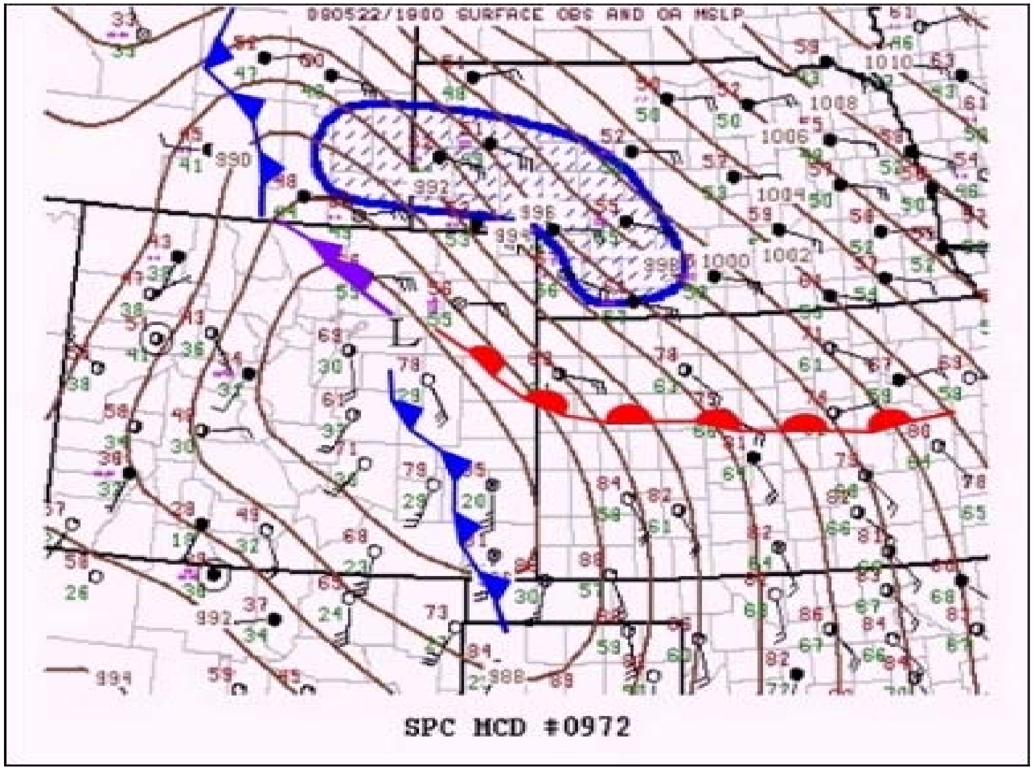


Figure 5: NOAA Storm Prediction Center (SPC) sea-level pressure analysis at 1900 UTC.
Wyoming is in the upper left corner. The blue hatched shading highlights a region with strong low-level shear.

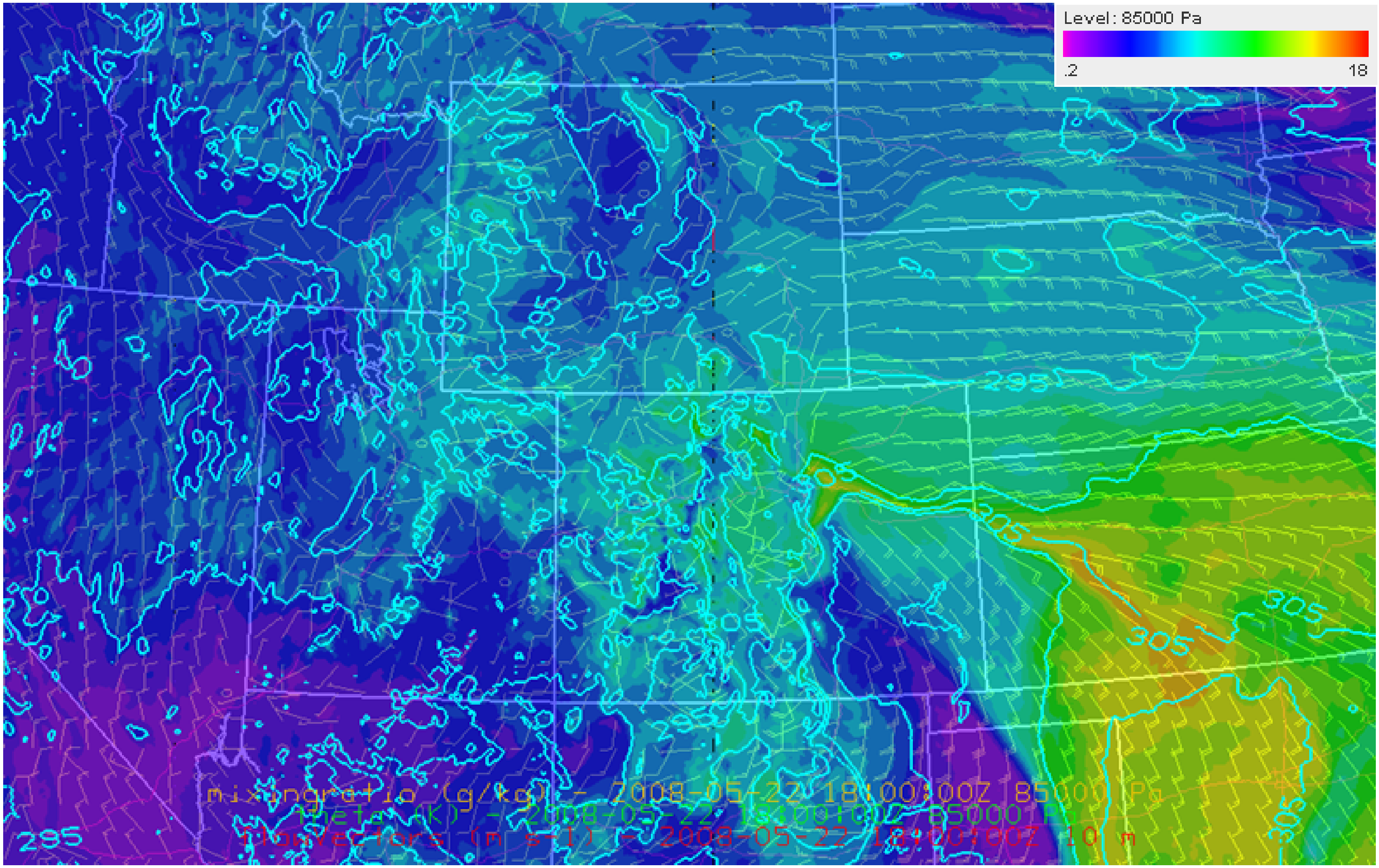


Figure 6: Surface winds (wind barbs), 850 hPa θ (cyan contours, 2.5 K interval) and 850 hPa mixing ratio (color fill, between 0.2 and 18 g kg^{-1}) at 1800 UTC, from the WRF-NMM.

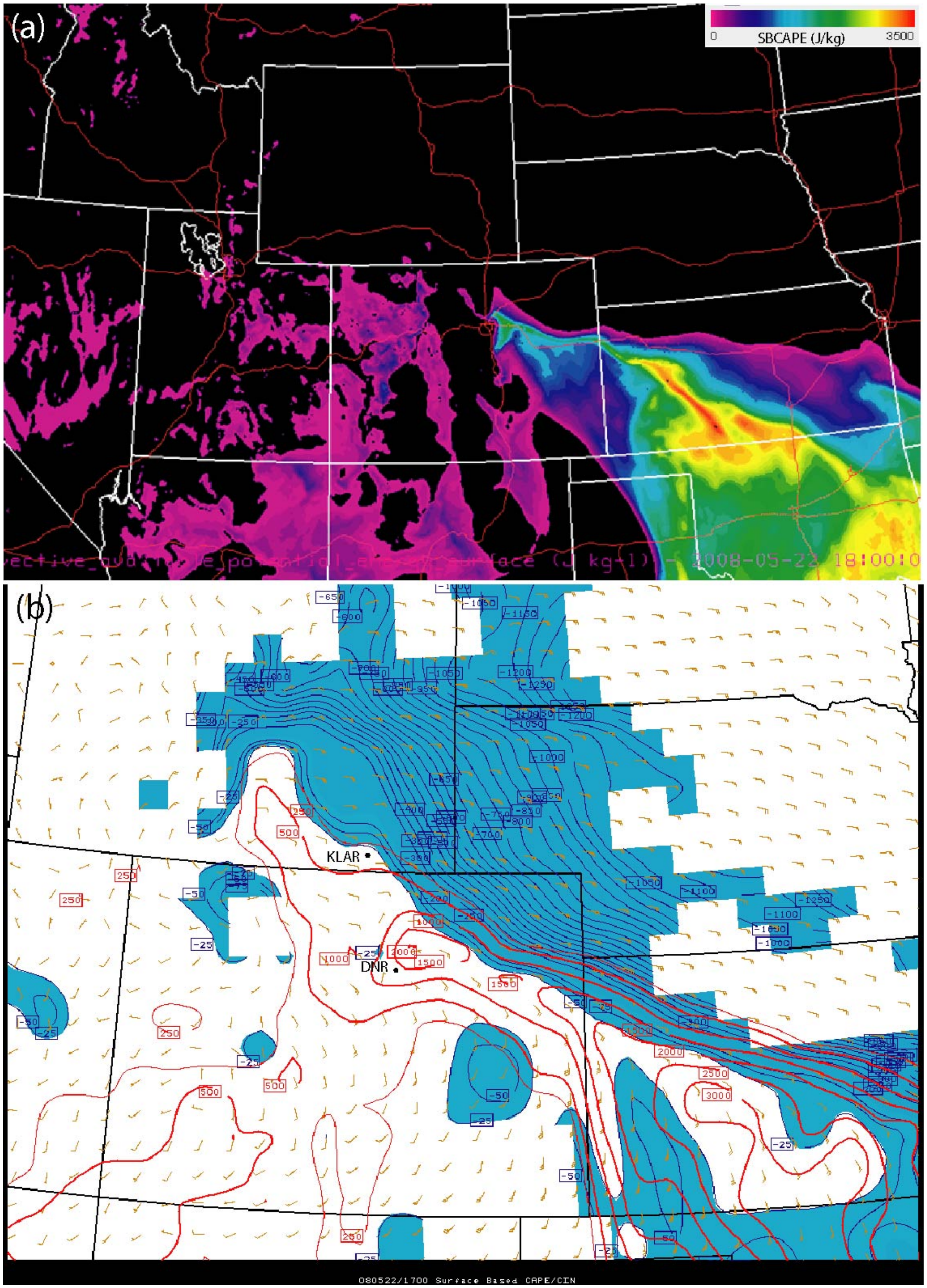


Figure 7: (a) SBCAPE (J kg^{-1}) at 1800 UTC from the WRF-NMM. (b) 1800 UTC SPC mesoscale analysis of SBCAPE (red contours, interval 500 J kg^{-1}) and SBCIN (blue contours, interval 50 J kg^{-1}), shaded blue where SBCIN <-25 J kg^{-1}.

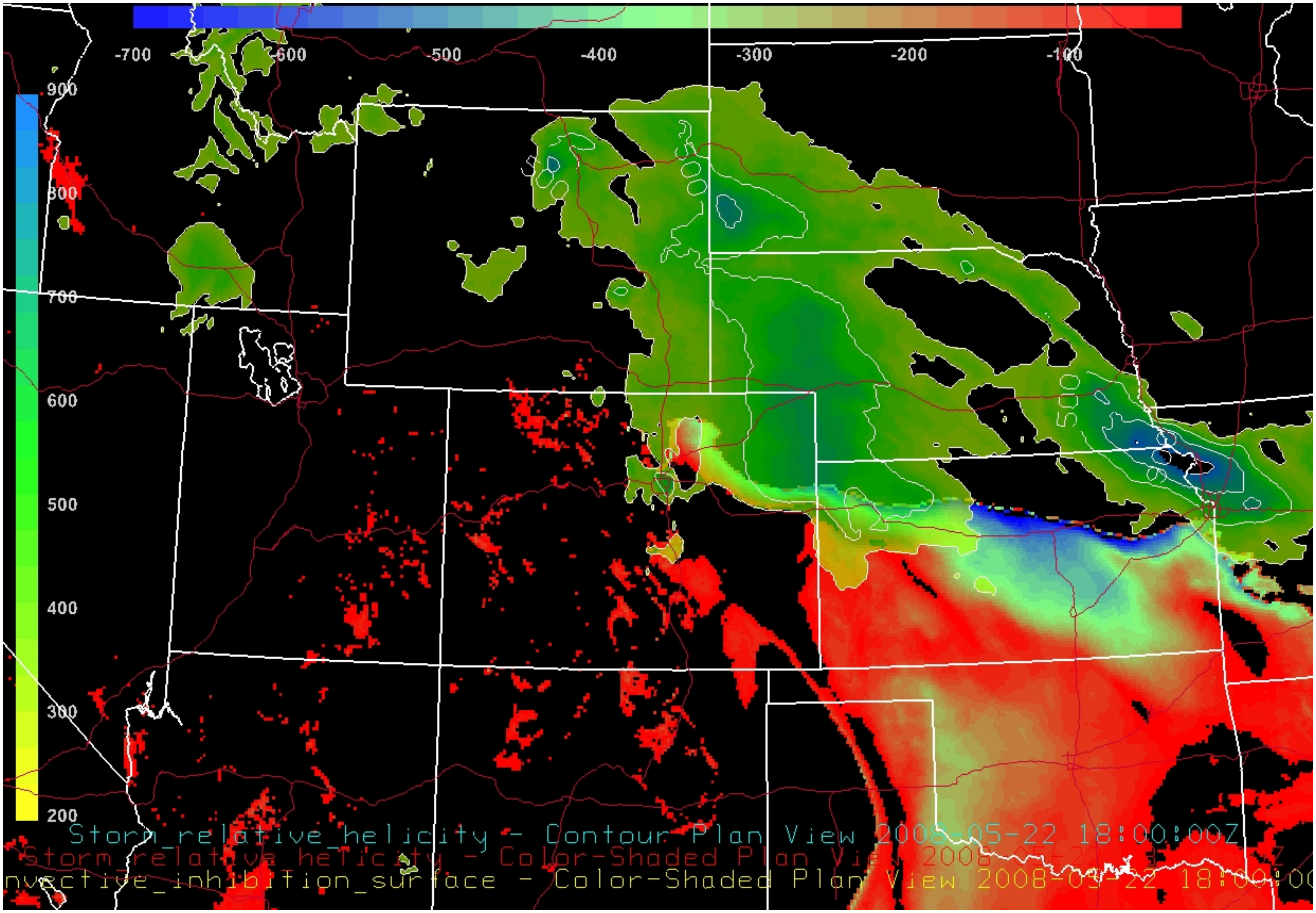
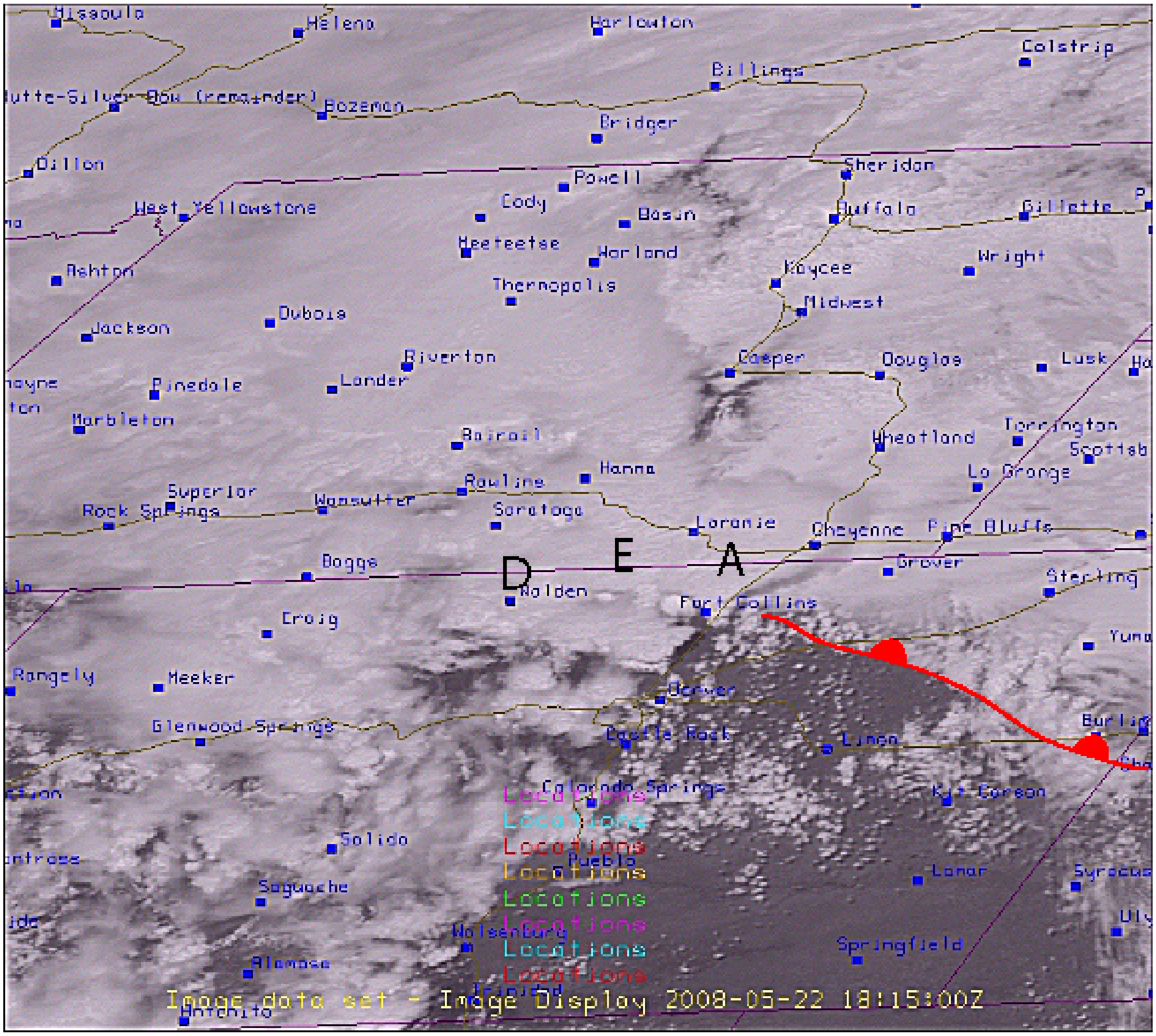


Figure 8: SBCIN (J kg^{-1}) in regions with non-zero SBCAPE, and 0-1500 m AGL SRH (m^2 s^{-2}) at 1800 UTC from the WRF-NMM. The key to SBCIN is on top (-700 <CIN< -25 J kg^{-1}), and the key to SRH (300 <SRH< 900 m^2 s^{-2}) is at left, with white contours every 200 m^2 s^{-2}.



<u>Figure 9</u>: NOAA GOES visible satellite imagery over Colorado and Wyoming, with frontal analysis at 1815 UTC. Click [here]() to view an animation from 1700 to 2000 UTC.

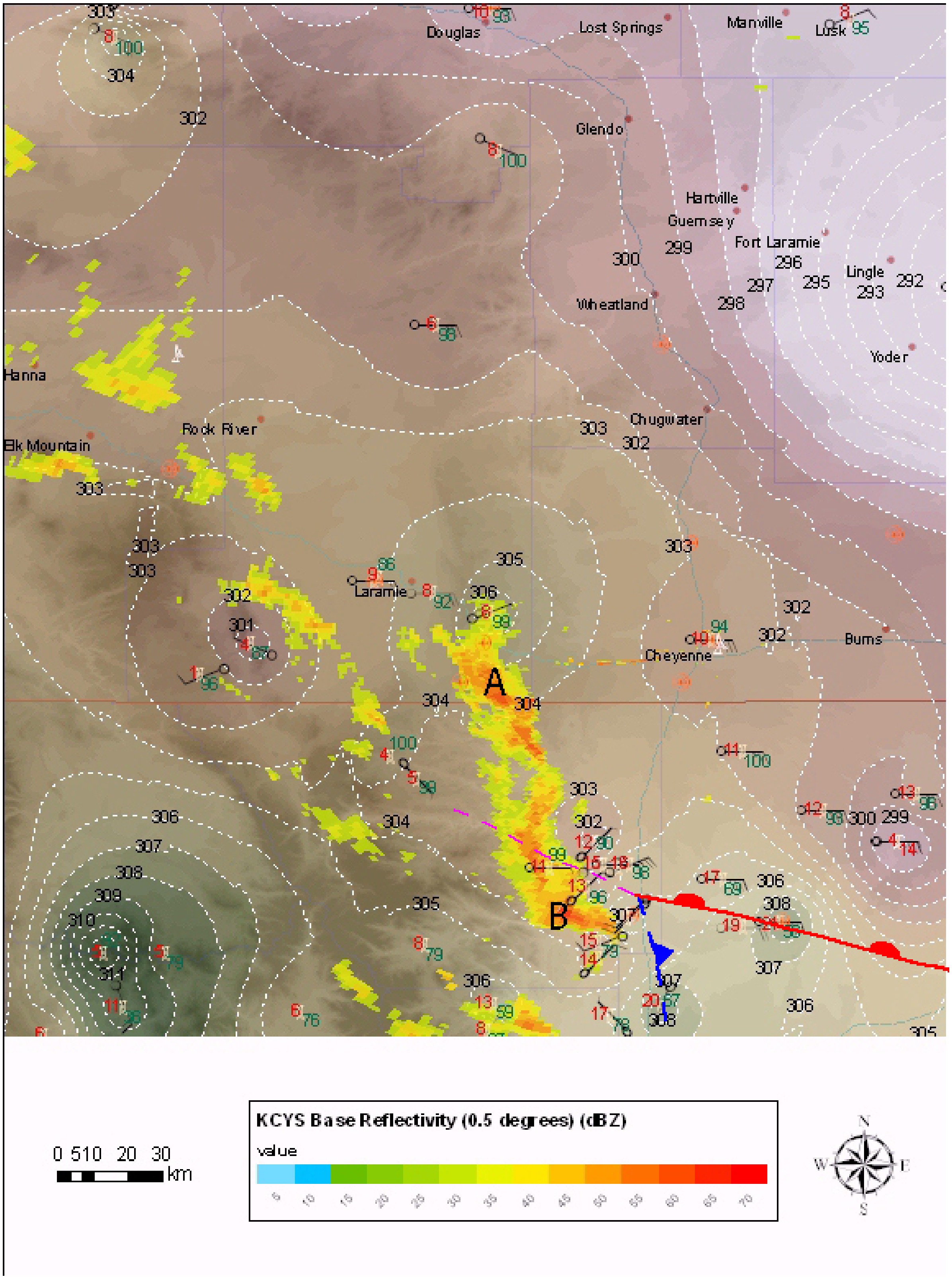


Figure 10: Objectively interpolated, observed θ (colored and contoured, 1K interval) and KCYS 0.5° radar reflectivity (colors in legend) over a terrain background (shading) at 1900 UTC. The temperature (red numbers), relative humidity (green numbers), and wind (one full barb is 5 m s^{-1}) are shown at each station, where available. Click here for an animation between 1800-2000 UTC.

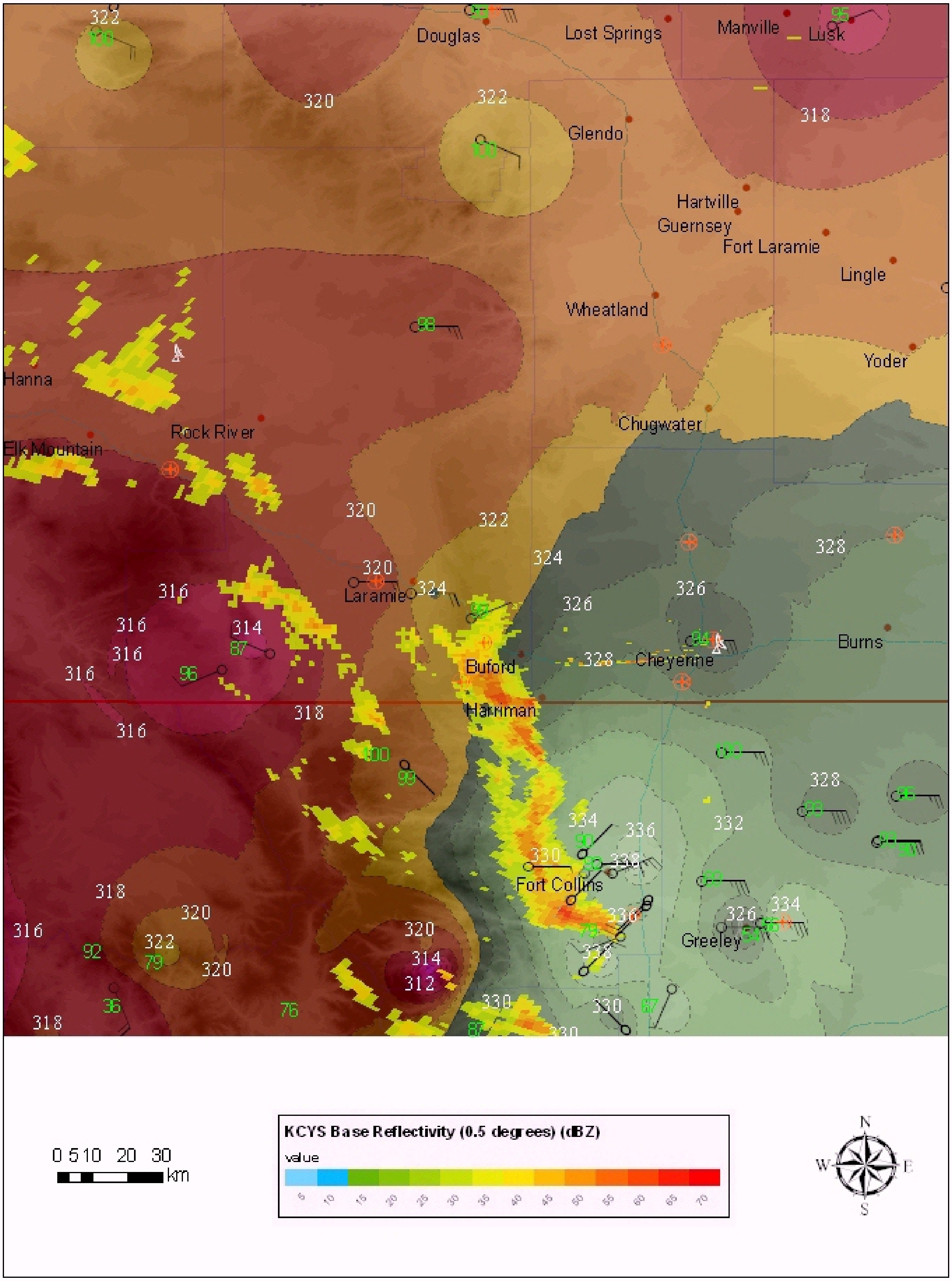


Figure 11: Objectively interpolated observed θ_e (colored and contoured, 2 K interval) and KCYS 0.5° radar reflectivity (warm colors) over a terrain background (shading) at 1900 UTC. The relative humidity (green numbers) and wind barbs are shown at each station, where available. Click here for an animation between 1800-2000 UTC.

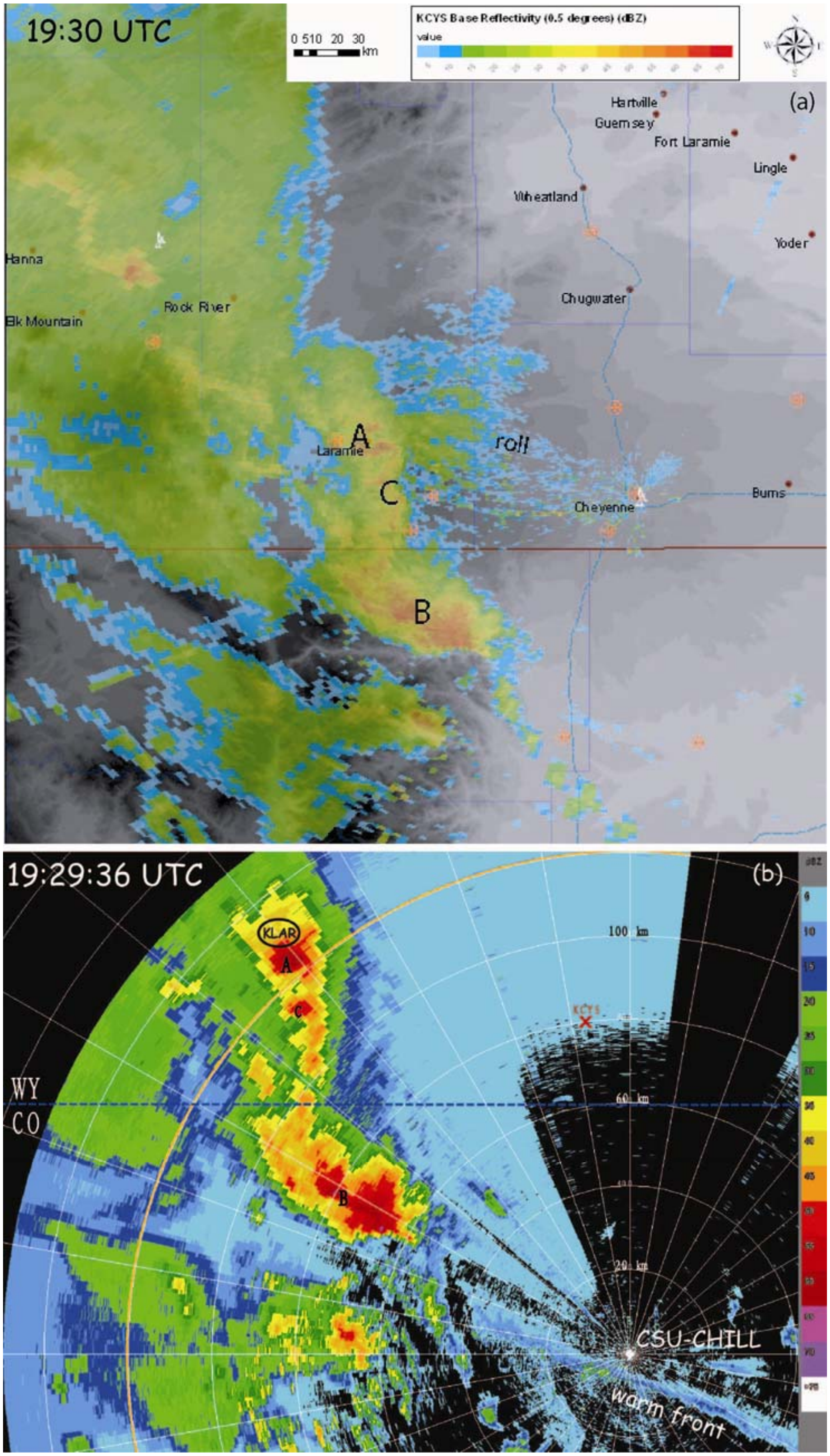


Figure 12: (a) KCYS WSR-88D base reflectivity (0.5° elevation) (dBZ) at 1930 UTC. Click here for an animation between 1830-2000 UTC. (b) CSU CHILL base reflectivity (0.5° elevation) (dBZ) at the same time. Click here for an 1830-2000 UTC animation. Range rings are plotted every 20 km. The black oval locates Laramie.

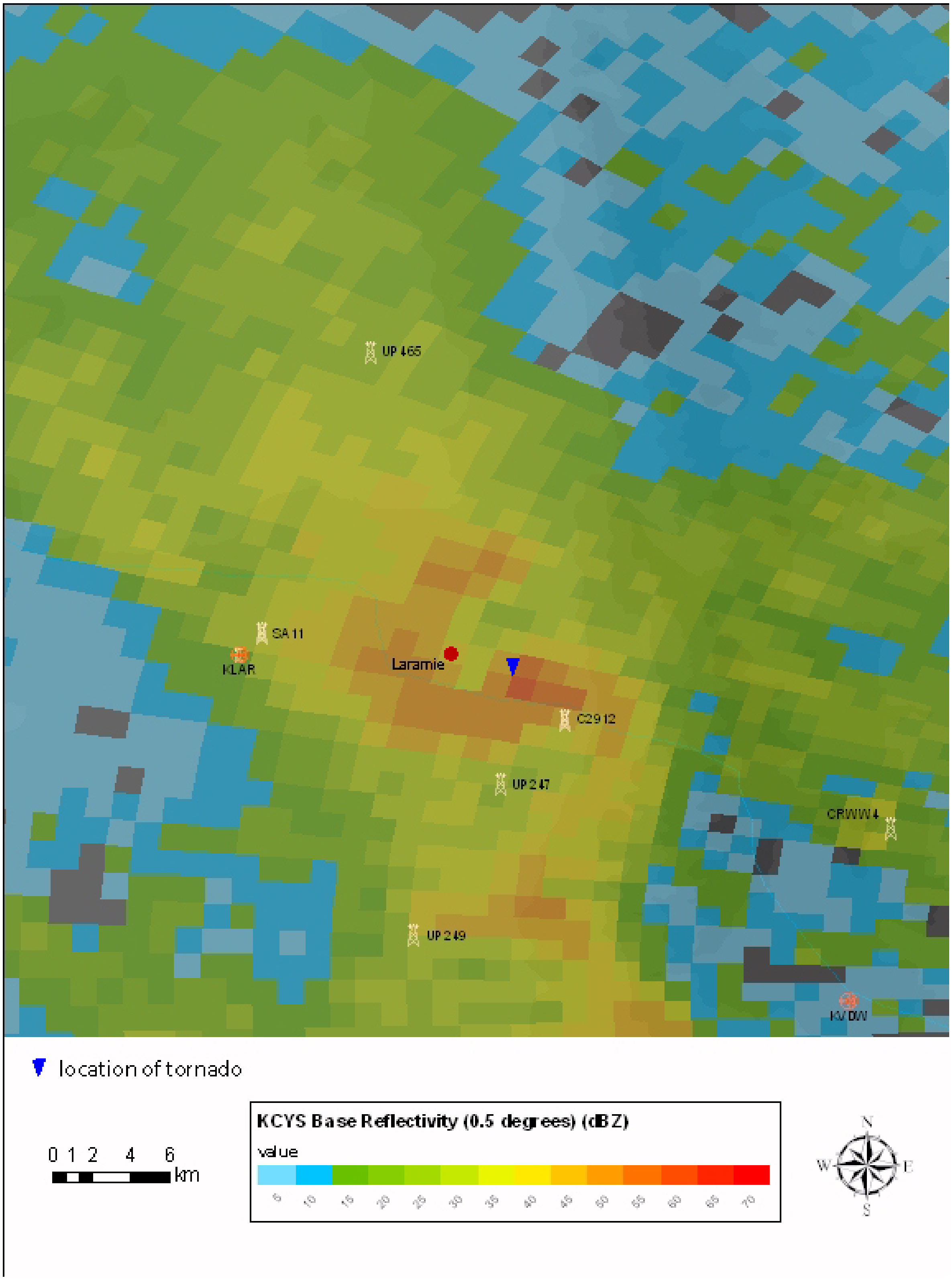


Figure 13: 1930 UTC KCYS radar reflectivity near Laramie, when the tornado struck the southeastern edge of Laramie. Click here for displays at increasing elevation angles. The height of the radar beam above Laramie is 1.2 km at 0.5°, 2.4 km at 1.5°, 3.5 km at 2.4°, and 4.7 km at 3.4°. The blue triangle marks the location of the tornado at the surface.

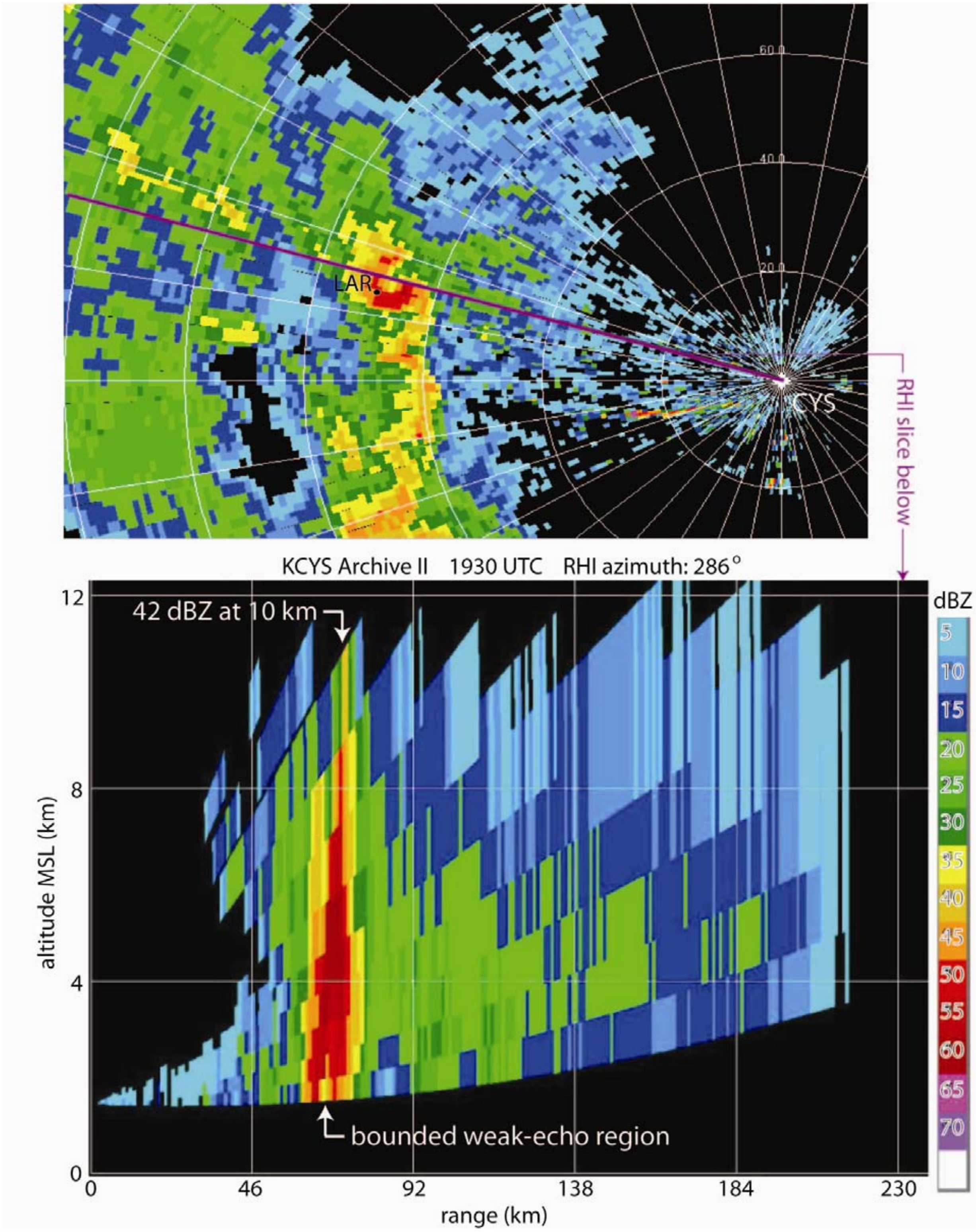


Figure 14: Vertical reflectivity slice from the KCYS WSR-88D radar at 1930 UTC, along an azimuth angle of 286° (purple line in insert image above).

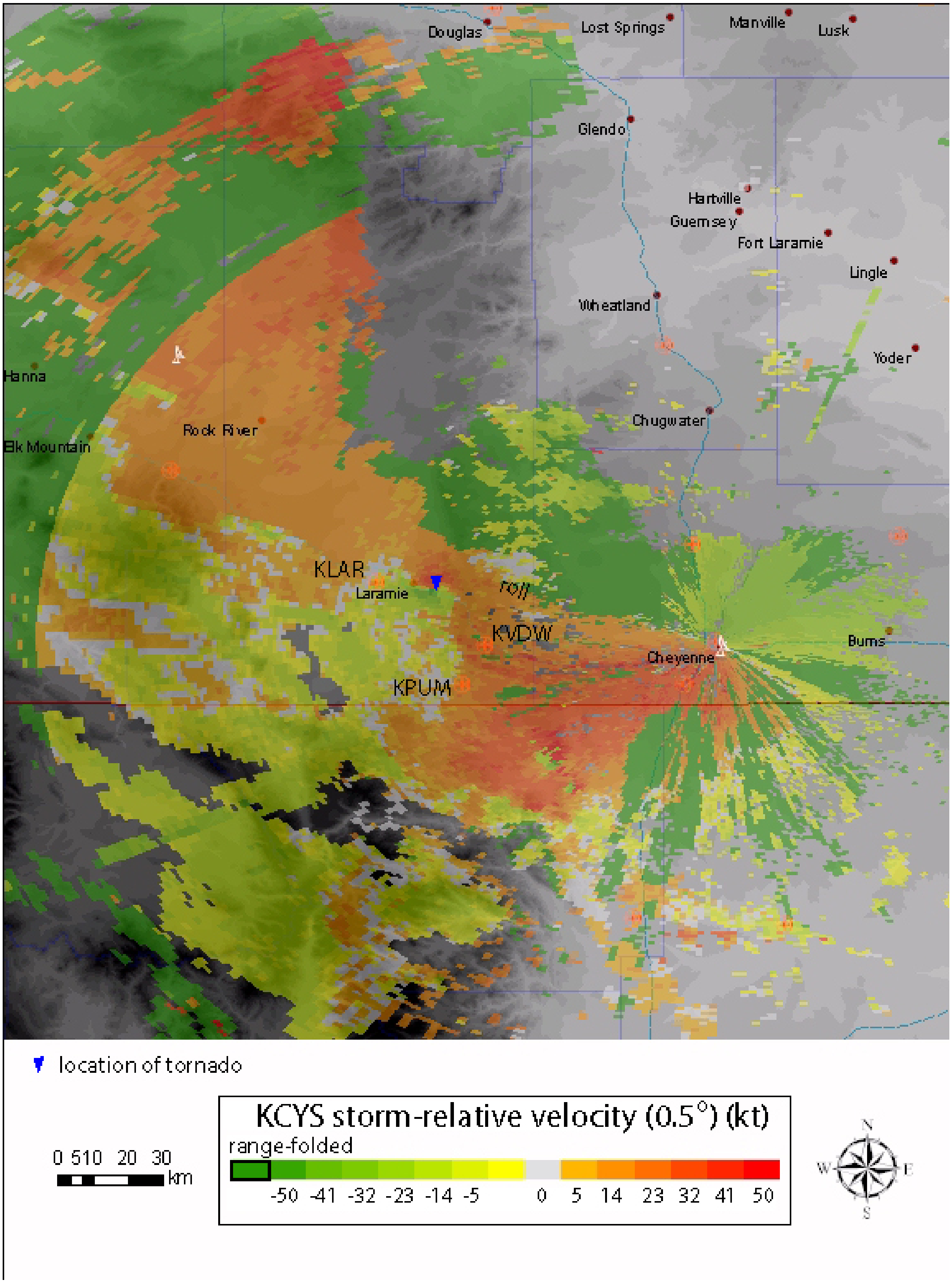


Figure 15: KCYS WSR-88D storm-relative velocity (0.5° elevation) (kt) at 1930 UTC. Click here for an animation.

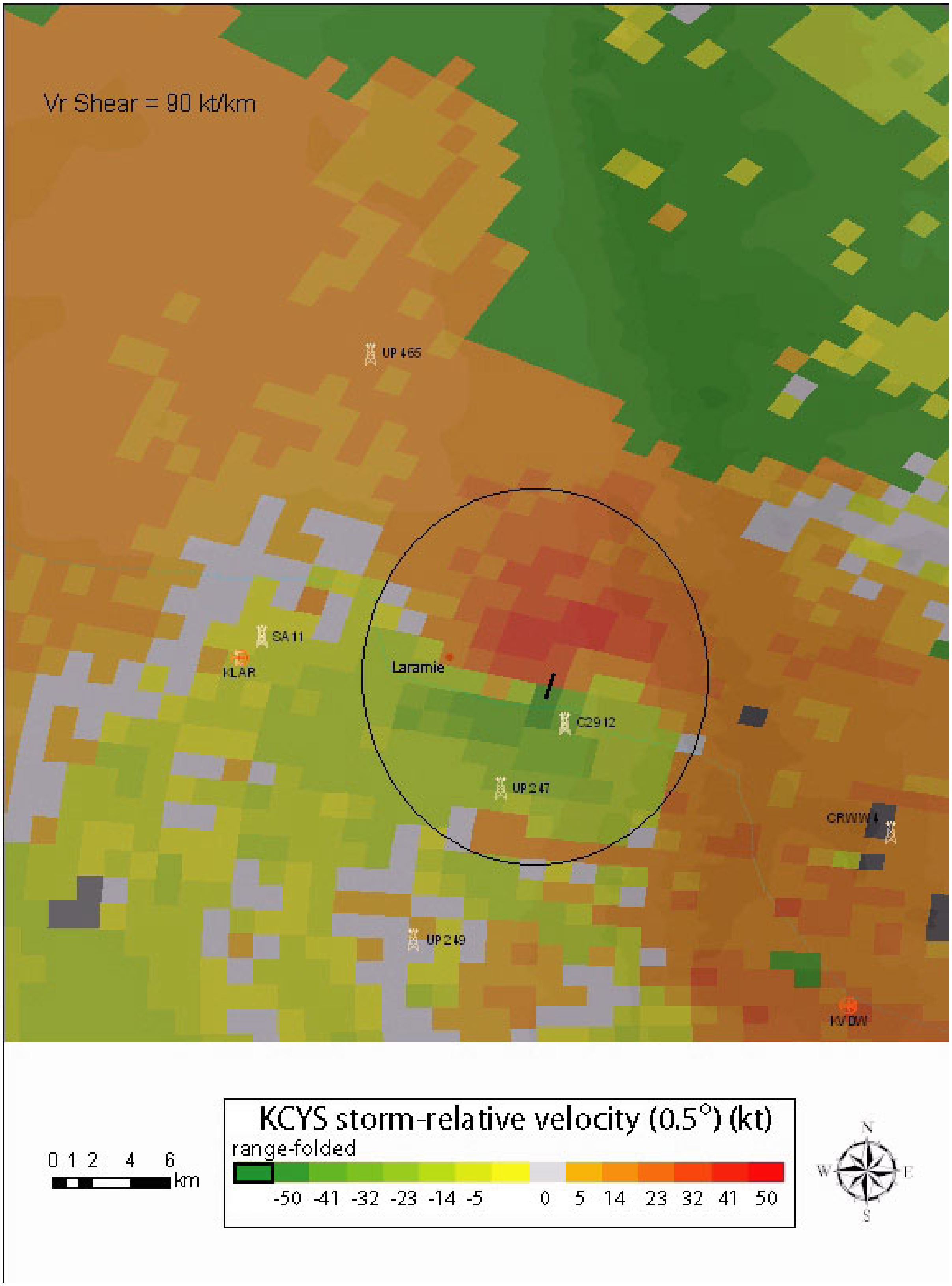


Figure 16: As in Fig. 15, but zoomed to the Laramie vicinity. Click here for displays at increasing elevation angles.

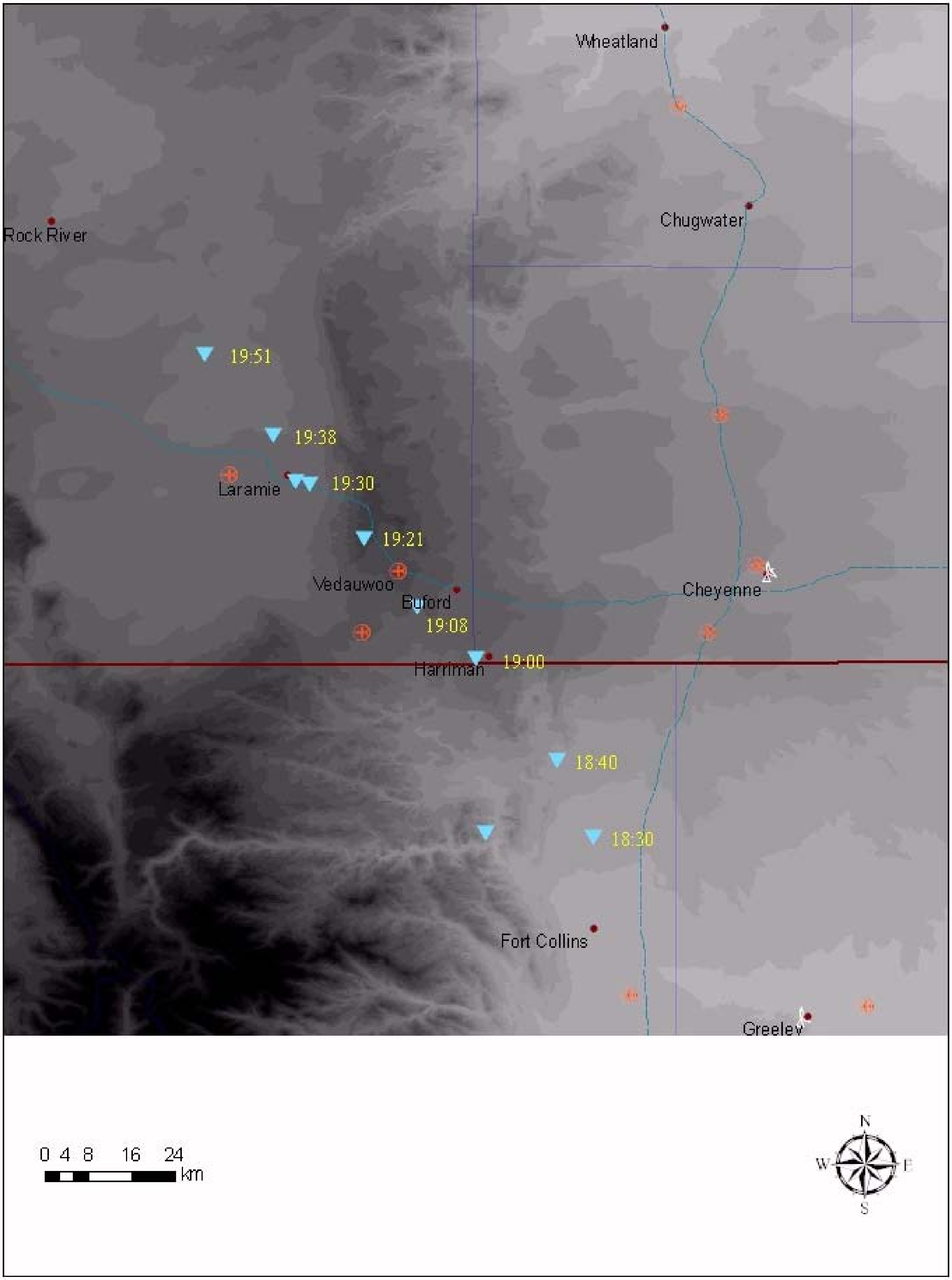
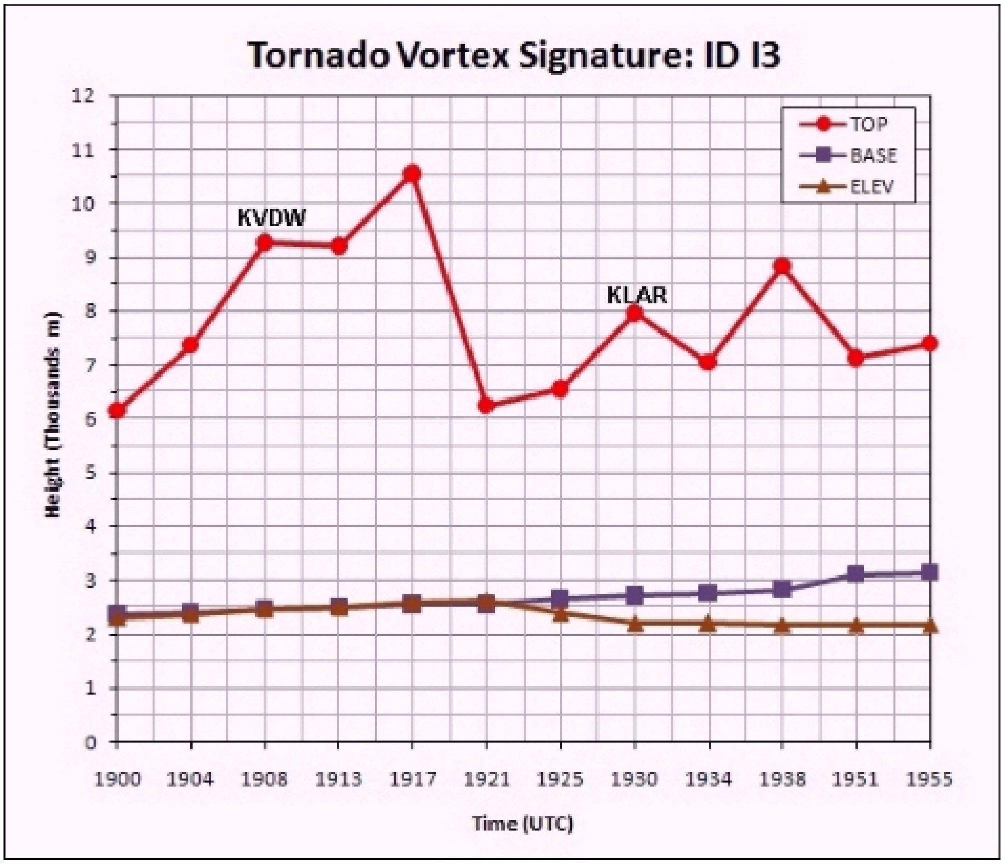
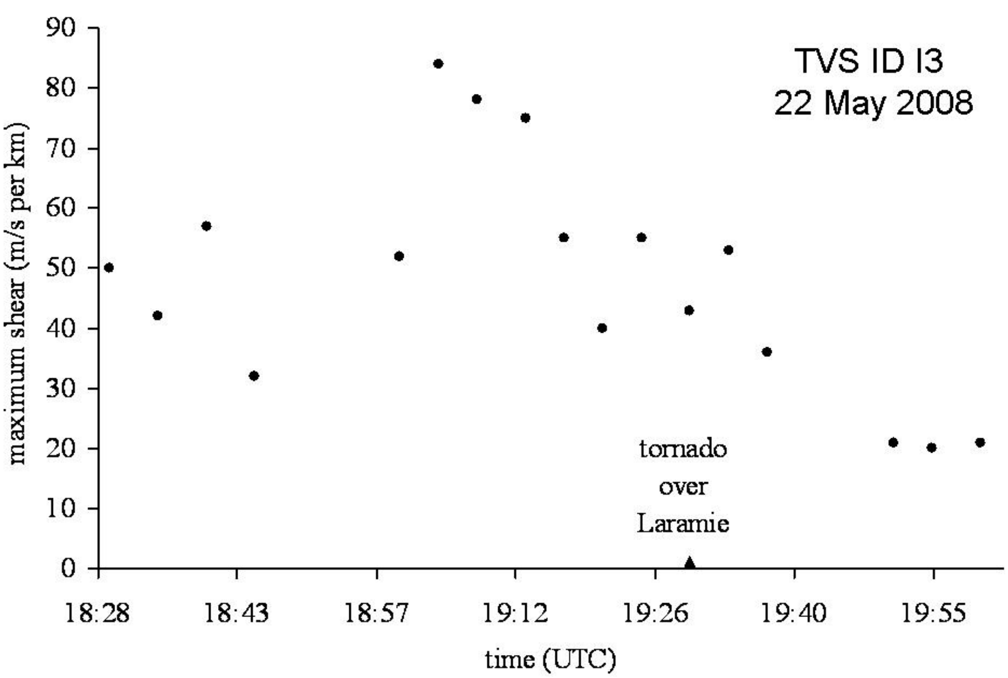


Figure 17: Track of the KCYS radar-detected TVS in storm 'A' (blue triangles), UTC times in yellow.



<u>Figure 18</u>: Evolution of the echo top and echo base of the TVS in storm ‘A’.
The brown line indicates the height of the underlying terrain.



<u>Figure 19</u>: Evolution of maximum cyclonic shear of the TVS in storm ‘A’, based on KCYS Level II radial velocity data at any elevation angle.

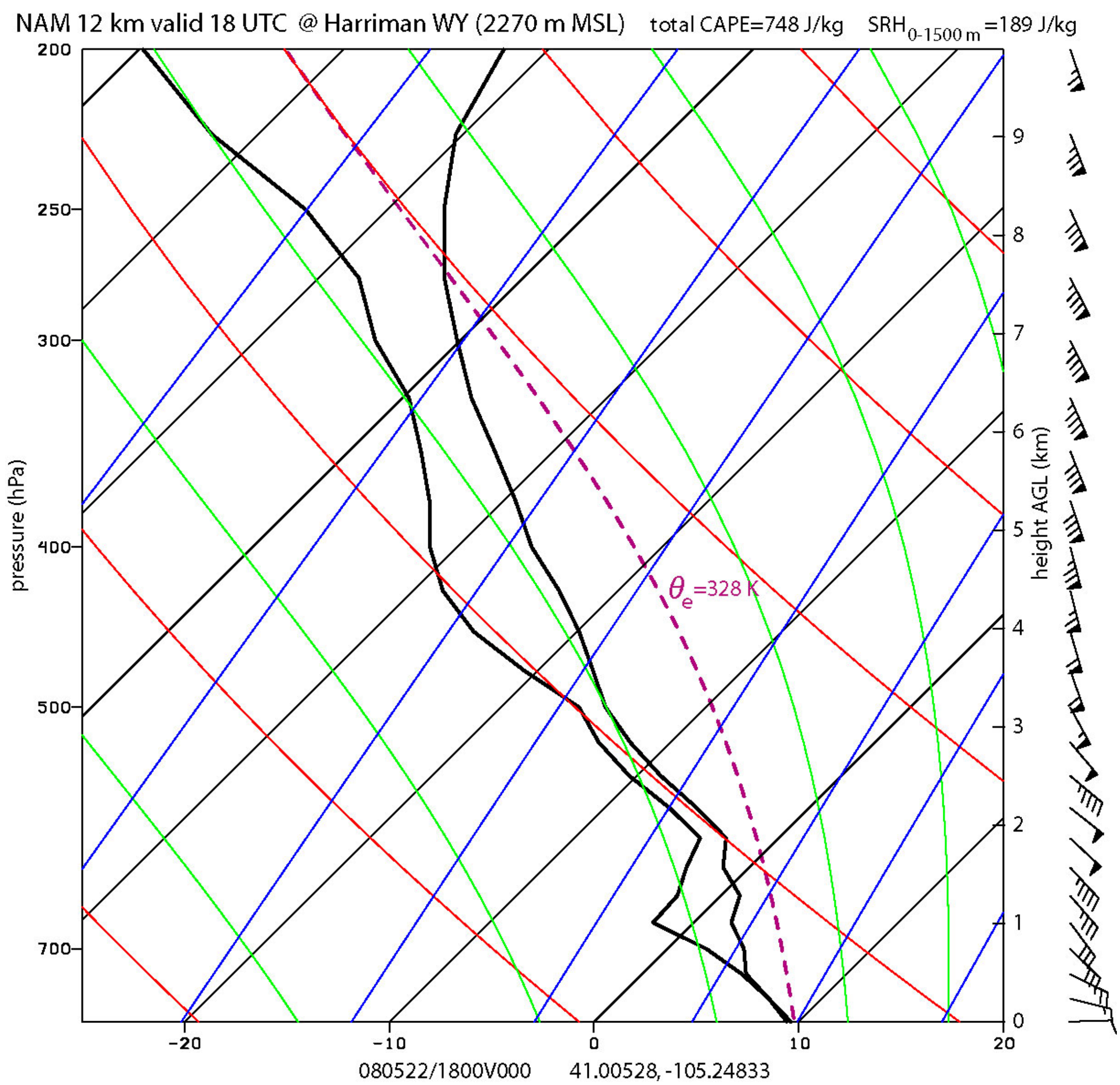


Figure 20: Model sounding from the 12 km NAM (initialized at 1800 UTC) at the location of Harriman (Fig. 1) at 1800 UTC.

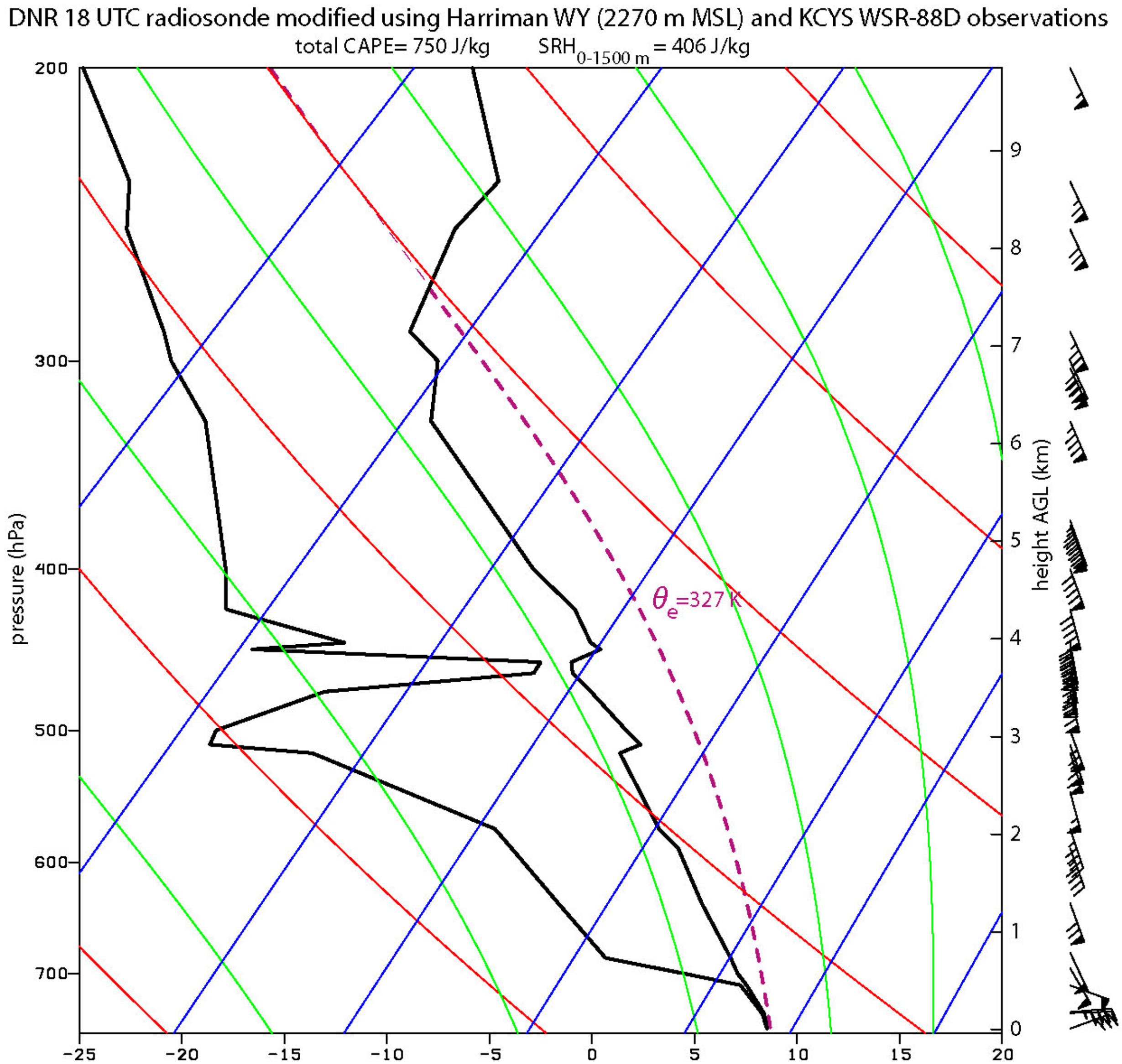


Figure 21: Observed Denver (DNR) sounding at 1800 UTC, modified with boundary-layer observations near Harriman at 1800 UTC.

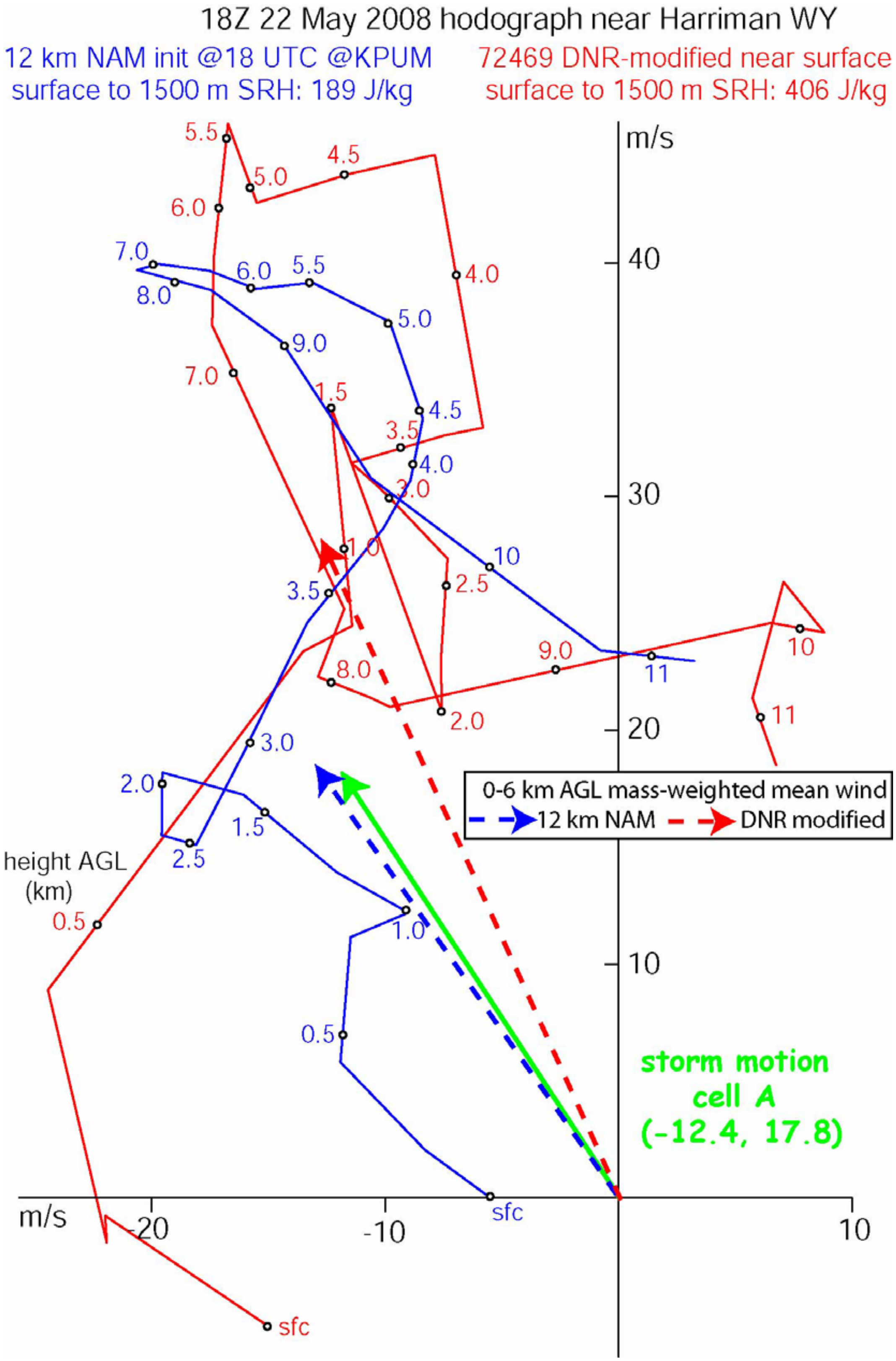


Figure 22: Two hodographs for Harriman at 1800 UTC. Red represents the 1800 UTC Denver radiosonde, modified as stated in the text. Blue represents the unmodified 12 km NAM initialized at 1800 UTC. Observed storm motion is in green.

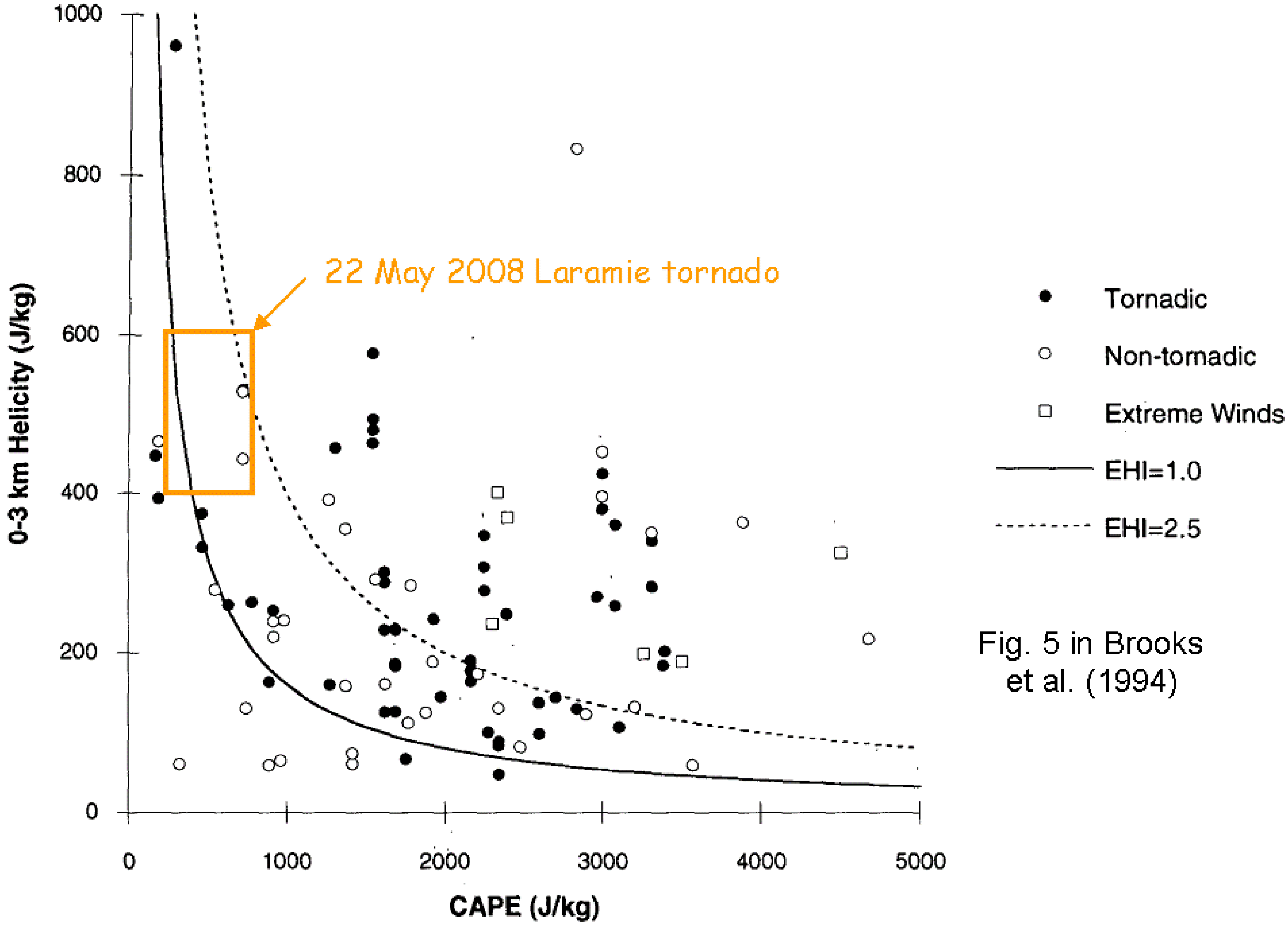


Figure 23: CAPE and 0-3 km SRH for the environment of the Laramie mesocyclone and of 112 mesocyclones, mostly in the central Great Plains [from Brooks et al. (1994)]. Energy-helicity index (EHI) isopleths of 1.0 and 2.5 are shown by a solid and a dashed line respectively.

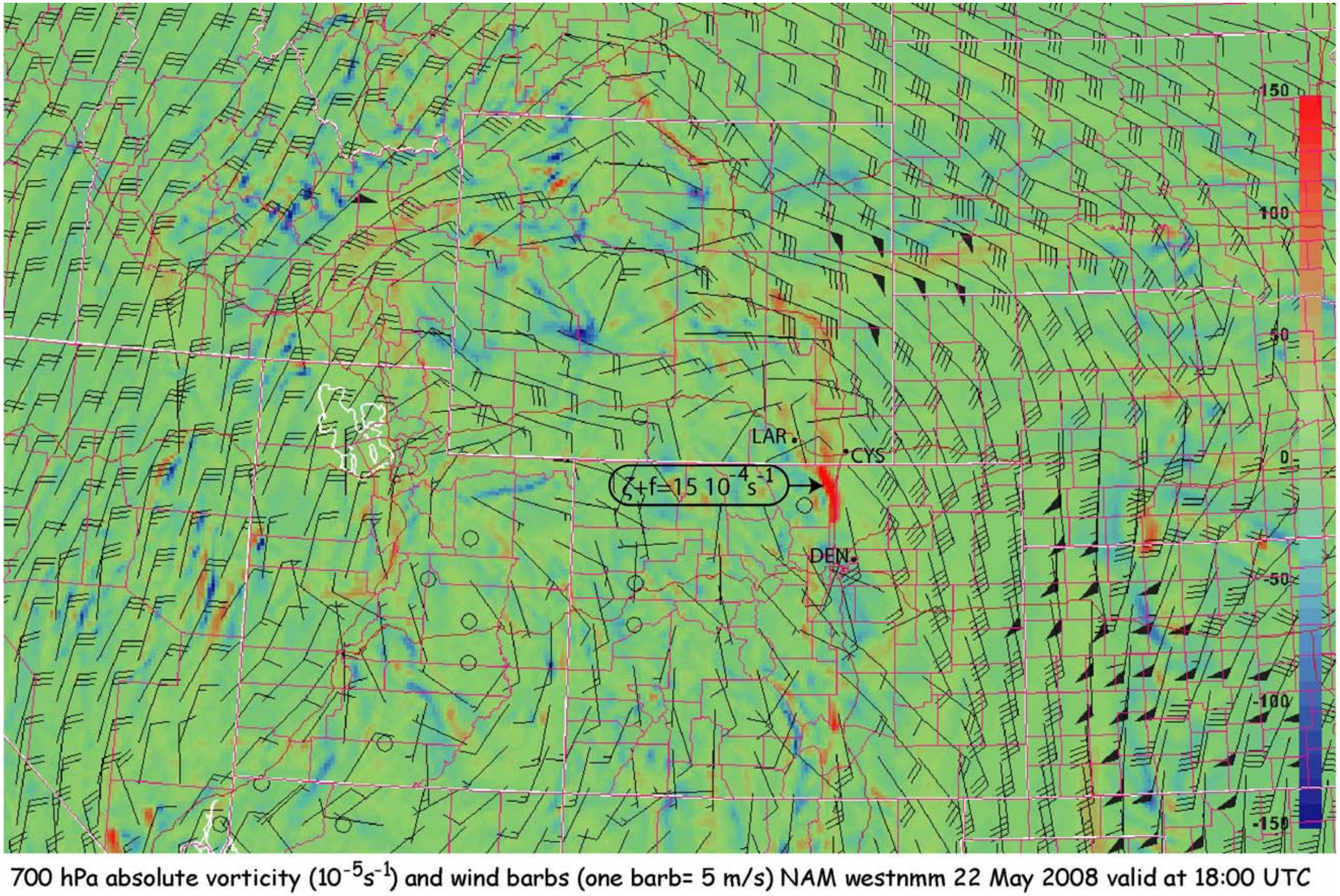


Figure 24: Absolute vorticity and wind at 700 hPa at 1800 UTC, according to the WRF-NMM. The location of Laramie (LAR), Cheyenne (CYS), and Denver (DEN)are highlighted.

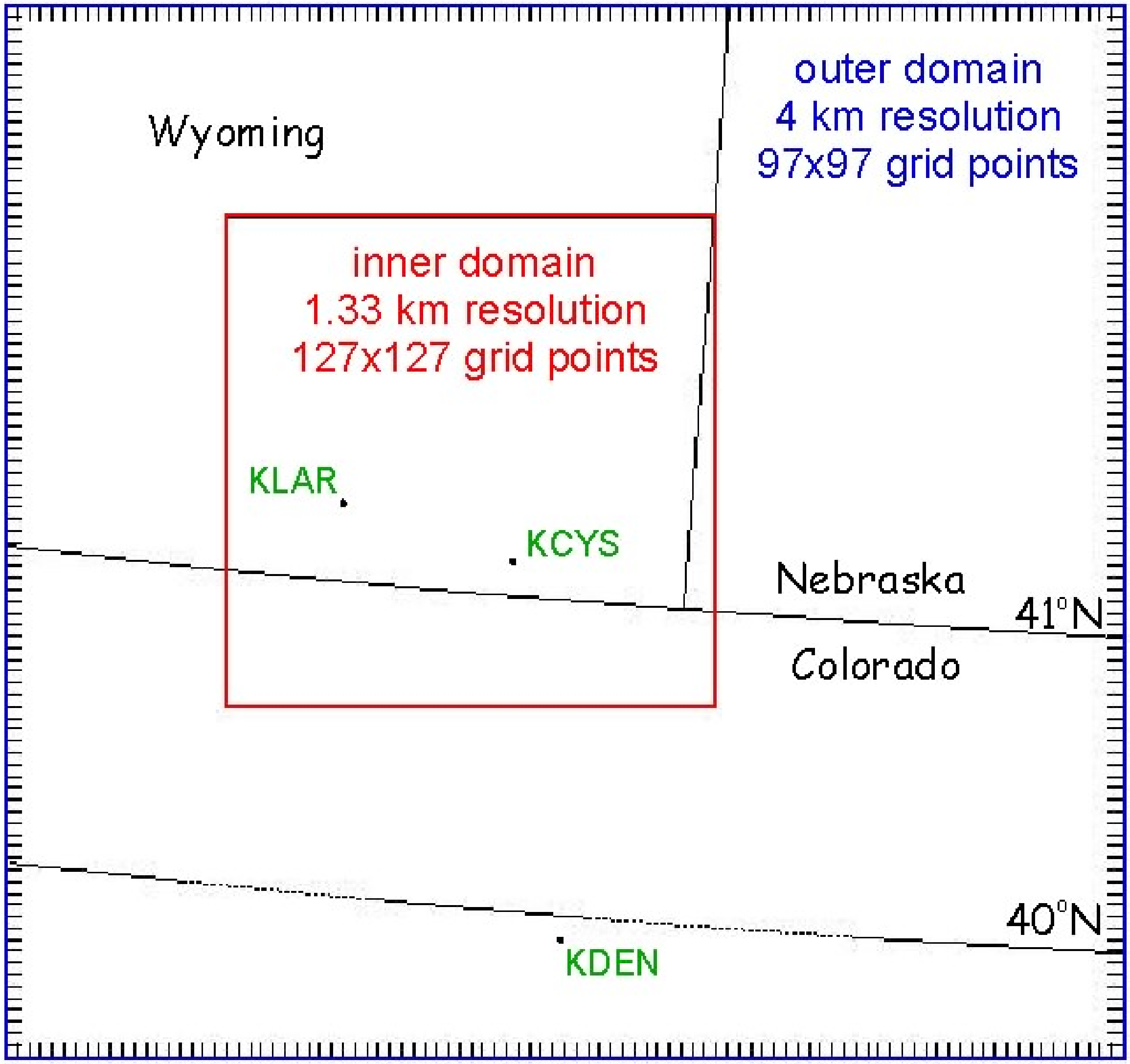
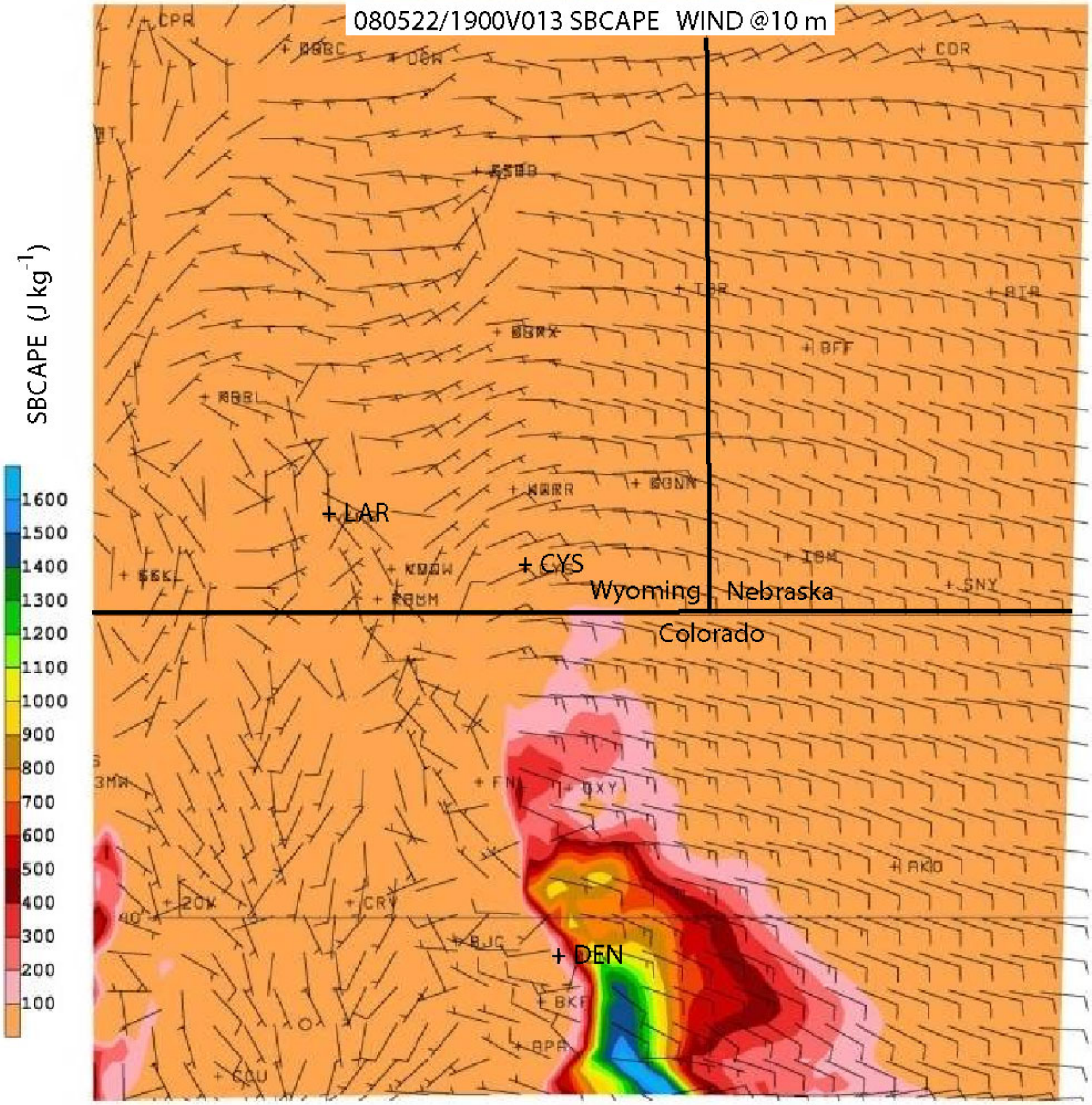


Figure 25: Outer and inner nest domain for the WRF simulations, with Laramie (KLAR), Denver (KDEN) and Cheyenne (KCYS) locations highlighted.



<u>Figure 26</u>: SBCAPE and 10 m winds at 1900 UTC in the outer WRF domain. Three-letter station identifiers are added to place model output in its geographic context.

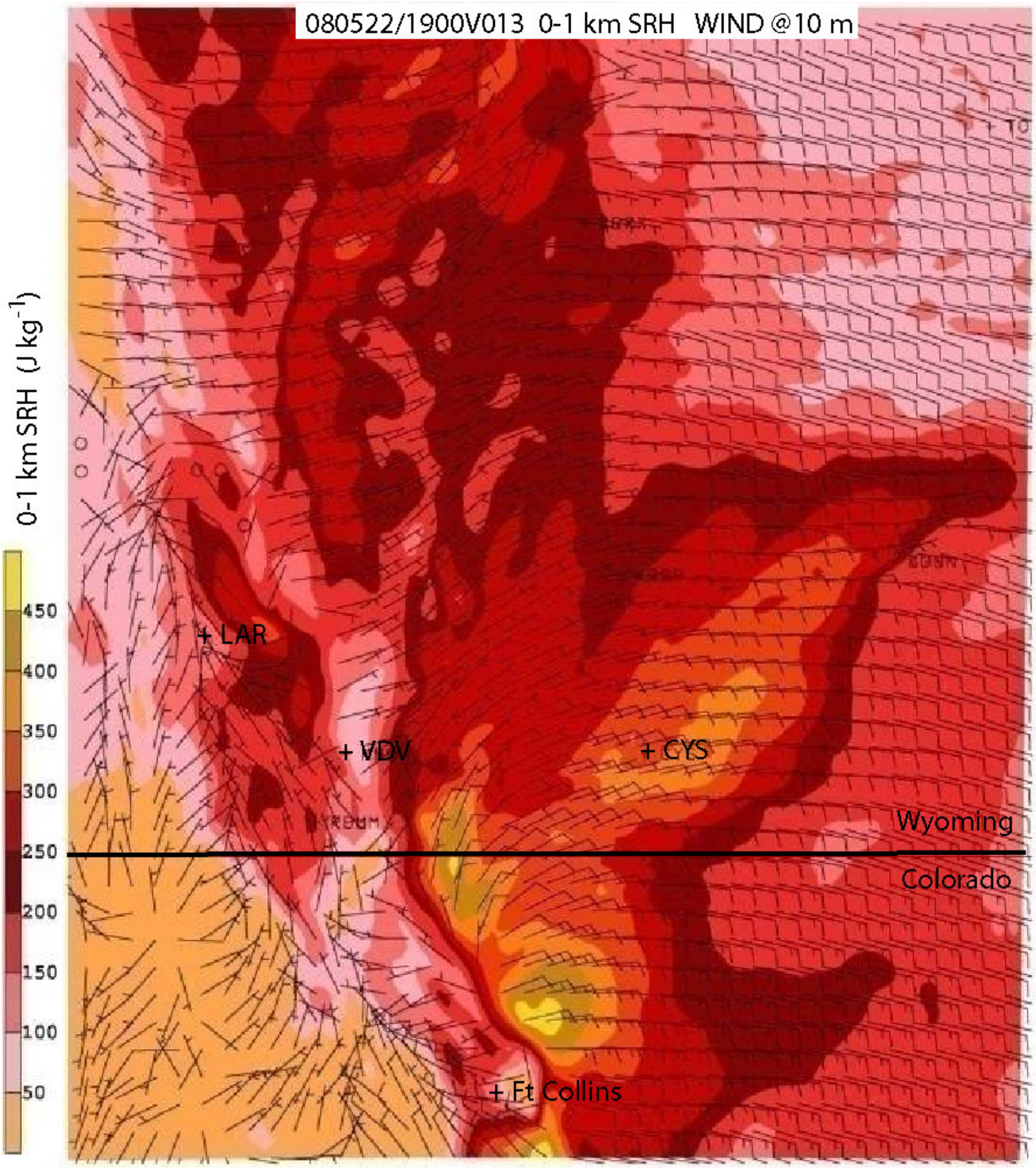


Figure 27: 0-1 km AGL SRH and 10 m winds at 1900 UTC in the inner WRF domain.

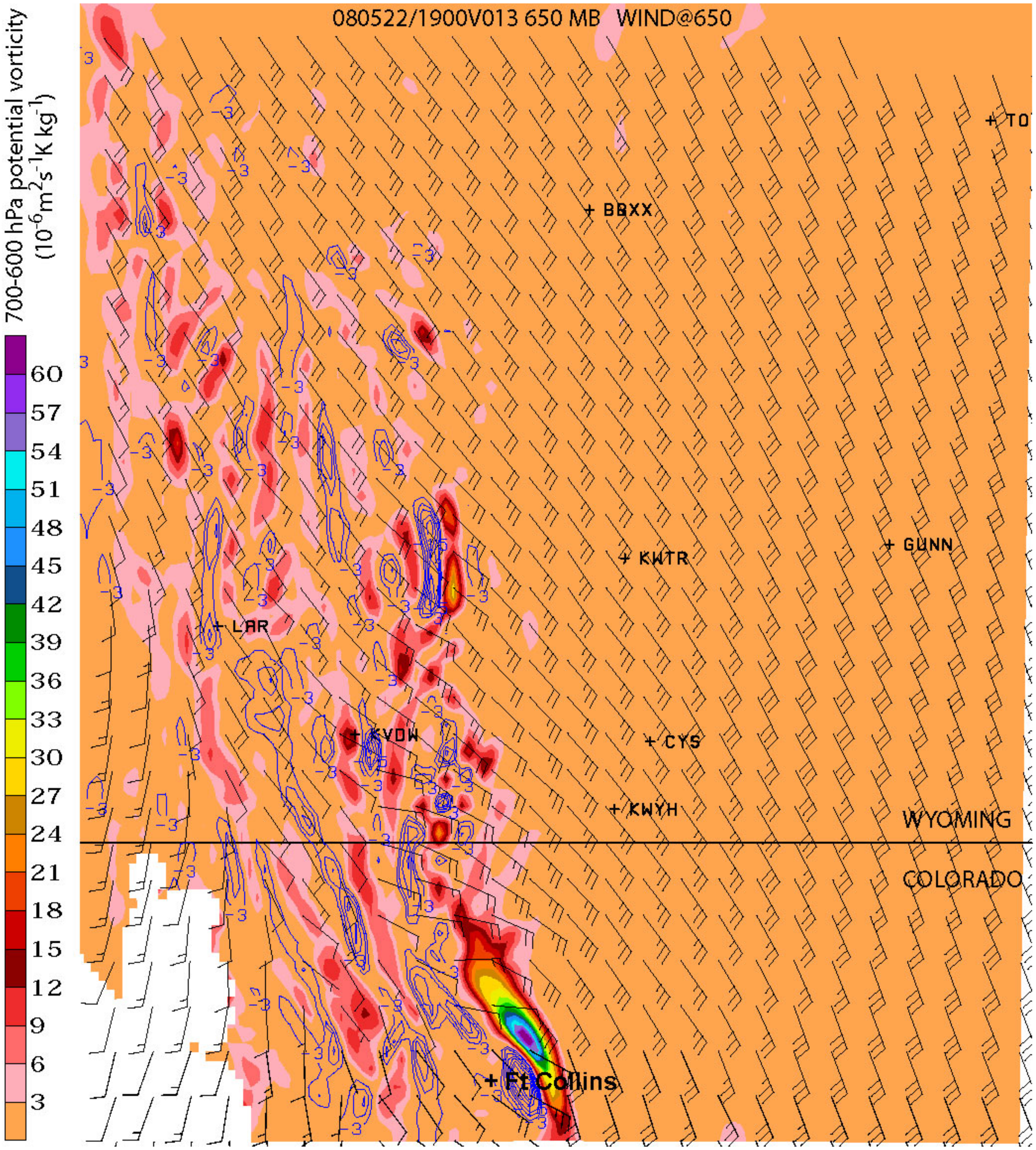


Figure 28: Potential vorticity between 700-600 hPa and 650 hPa wind (barbs) at 1900 UTC in the inner domain. Positive PV values are color-filled (in PVU) while negative vorticity is shown in blue contours (interval of 3 PVU). The white area in the lower left corner has terrain above 700 hPa.

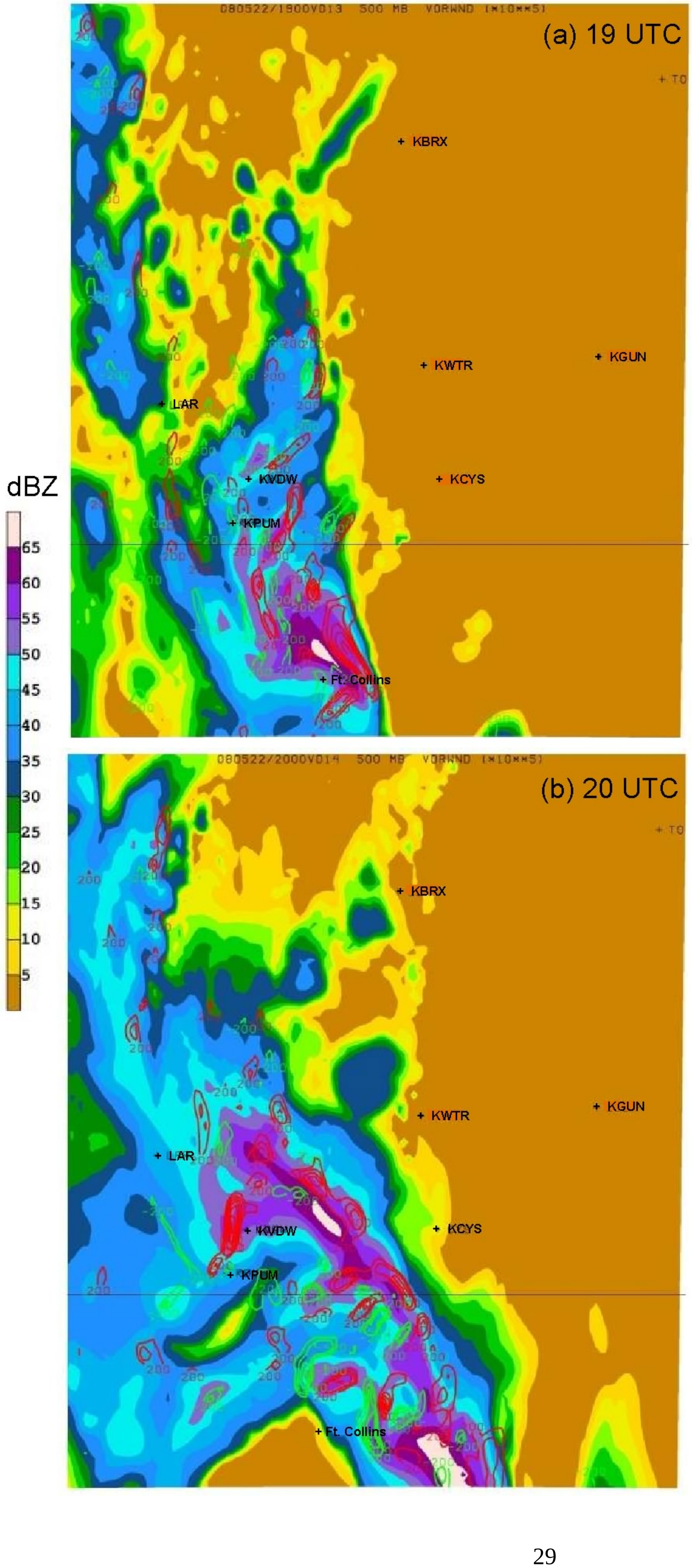


Figure 29: Maximum reflectivity at any level, calculated from the WRF bulk microphysics scheme assuming Rayleigh scattering (color fill, dBZ), overlaid with 500 hPa positive (red contours) and negative (green contours) relative vorticity (contour interval: 5×10^{-4} s^{-1}) in the inner domain, at (a) 1900 UTC and (b) 2000 UTC.